

Construction and method in electric motor drive

The object of this invention is the construction in electric motor drive, where an asynchronous motor, such as drum motor or similar motor, which has a stator mounted on a non-rotatory shaft and around the stator is a rotor, which is rotatory, like by means of bearings, connected on the same shaft and has a short-circuit arrangement, is arranged to drive a machine construction (actuator).

Above described types of asynchronous, compact drum
motors have been presented for example in publications
15 EP 0 582 563,
US 4,868,436 and FI 811414. Among these, the first-
mentioned solution is carried into effect by keeping
separate and individual copper short-circuit bars in
their position by pressing them in place with collars
20 mounted on the end flanges of the motor.

The disadvantage of this type of solution is the poor heat transmission from the short-circuit bars to the rotor shell. Further in the solution of US-patent 4,868,436 the rotor structure is built up of so called active part i.e. electric plate package and at least two separate rotor shell parts i.e. support flange and onto it by means of screw coupling connected rotor shell, which makes the solution in question unnecessarily complicated. In application publication EP 0 617 155 there is a much similar solution (of above mentioned U.S.-patent), where motor's rotor package, which is constructed/laminated of electric plates, is

connected together with it's short-circuiting
conductors to drum roller by means of screw/press
coupling, which operates as a roll surface. Also this
solution is disadvantageous especially in
5 manufacturing. Further in latter Finnish patent
application is presented a drum motor, which is
designed especially for

10 elevator purposes. In this solution a separate roller
with cable grooves and brake surface area for
elevator's lifting cables and brakes is mounted on the
upper shell of the rotor. E.g. in this solution is
additionally proposed that the motor cooling is taken
care of by machining radial ventilation holes in the
15 roller and stator and to blow the cooling air to the
holes with a separate blower.

To all of the above mentioned solutions it is common,
that first of all respectively used machine
20 construction (actuator)'s connection to the drum motor
requires special mounting arrangements and/or extra
parts for it i.e. a separate drive roll to be assembled
on to an electrical motor's rotor (EP 0 582 563), a
firmly assembled flange arrangement on the motor's
25 frame (US 4,868,436) or a shell to be assembled outside
the drum motor (FI 811414 and
EP 0 617 155 A1). On the other hand in the motor
constructions in the above mentioned innovations the
cooling circulation is carried out by traditional
30 means, thus it is not possible to reach higher outputs
than with standard drum motor solutions.

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The purpose of the construction of this invention is to overcome the above-described disadvantages and thereby essentially improve the level of the technique in this area. It is principally distinctive to the construction according to this invention, to carry out this purpose, that the functional part of the machine construction (actuator), like conveyor's driving roll or similar, is arranged to operate by having short-circuit arrangement as the rotor of the asynchronous motor. In other words: the "actuator" (e.g. driving roll) is formed to constitute itself the rotor of the asynchronous motor, with the actuator comprising the short-circuit arrangement.

15 The construction according to the invention is characterized by that the functional part of the machine construction (actuator), like conveyor's driving roll, is arranged to operate by having short-circuit arrangement as the rotor of the asynchronous motor.

It should be noted that the term "actuator comprising the short-circuit arrangement" is referring to many various (or different) embodiments. In the most simple embodiment, the actuator is formed as a one-piece solid roll shell being free from short-circuit bars and rings (also being free from laminated elements).

30 In another embodiment (also being free from laminated elements) short-circuit bars and rings are provided. Each of the bars and the rings will be located within the roll shell, preferably with a tight or positive fit

(or locking) being provided between each bar and the roll shell, whereby additional mounting elements (e.g. collars and/or screws) are no more needed.

- 5 The most important advantages of the construction of this invention is the simplicity of its construction, manufacturing and usage, efficiency and reliability of working, which attain the most possible integrated and compact machine configuration, which allow to get
- 10 higher output and higher torque from the used asynchronous massive rotor and significantly to improve its performance in other ways too. The simplicity of the construction of this invention as advantageous solution is based e.g. on fact there is no need to use
- 15 traditional short-circuiting conductors, as the short-circuit arrangement is established directly into the functional part of the machine construction (actuator), like conveyor's driving roll. On the other hand the structure of
- 20 this invention makes it possible to use the traditional short-circuiting connectors in a new way, so that they are located essentially internally on a functional part of the machine construction (actuator) as the rotor shell, like conveyor's driving roll. When applying
- 25 advantageously the structure of this invention, the asynchronous motor is equipped with primary and secondary cooling circulation to cool both the stator and the rotor for example so that the cooling fluid is firstly essentially carried through the stator shaft
- 30 and with the help of the holes in the shaft elsewhere as parallel flow through the flow system in the rotor shell. As a further improvement the rotor is manufactured of electric conductive compound metal

Object of this invention is also a method for equivalent purpose, which is more specifically described in independent patent claim's introduction

section and whose characteristic features in corresponding patent claim's characteristic section.

5 The method according to the invention is characterized by that the functional part of the machine construction (actuator), like conveyor's driving roll, is arranged to operate by having short-circuit arrangement as the rotor of the asynchronous motor.

10 One of the most important advantages the method of this invention has, is the simplicity of the operating principle and the simple constructions which makes it possible and the reliability of working and which
15 allows to gain the utmost compact machine construction (actuator) unit with integrally united asynchronous motor to achieve high mechanical load capacity, vibration strength and high starting and operation torque features. The simplicity of the method of this
20 invention as a advantageous solution is based for example on the fact that there is no need to use a separate laminated rotor component with traditional short-circuiting conductors inside a functional part of the machine construction, by establishing a short-
25 circuit arrangement directly into the functional part of the machine construction (actuator), like conveyor's driving roll. On the other hand the method of this invention makes it possible to use the traditional short-circuiting connectors in a new way, so that they
30 are located essentially internally on a functional part of the machine construction (actuator) as the rotor shell, like conveyor's driving roll.

Furthermore as an advantageous development of this innovation, it is possible to increase an air gap diameter between stator and rotor once a maximum outer diameter and total length of a drum motor is limited. 5
Thus by this innovative design it is possible to get higher output power and higher torque compared to an asynchronous drum motor having same main dimensions as this new innovative drum motor construction and having 10
a standard laminated rotor component inside a rotor shell.

Furthermore as an advantageous development of this method is to minimize the manufacturing costs of the 15
here mentioned massive motor for example by manufacturing the rotor and the associated slots by casting them of steel.

Applying the method advantageously the asynchronous 20
motor is being cooled effectively to get higher output than with conventional ones can be reached, because correctly carried out i.e. according to this invention realized for example hermetic and essentially in axial direction trough the asynchronous motor carried cooling 25
fluid flow makes it possible for example to direct the over-press cooling air to the hottest spots of the rotor, which is an essential condition both to increase the maximum output and to increase the amount of starts/stops. On the other hand compared to the freely 30
breathing air-cooled solutions this solution prevents especially in hard conditions filth to penetrate into the drum motor structure.

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Cooling of asynchronous motor with a solid rotor can be realised either with or without a secondary cooling arrangement via hollow bars or tubes inside a functional part of the machine construction (actuator) as the rotor shell. In such constructions the cooling is taken care of only with a primary cooling arrangement (e.g. air flow arrangement though an air gap between an inner surface of rotor shell and an outer surface of stator component.

Furthermore it is important that the short-circuit bars and rings belonging advantageously to the short-circuiting adjustment are arranged essentially integral with rotor shell i.e. at least partly or then totally with internal arrangements, and thus also a much more efficient heat conduction than present, between the steel shell and the copper short-circuit bars and rings can accomplished than with the traditional solutions. This also gives better possibilities for higher output and to increase the starts and stops of the asynchronous motor within a certain time interval.

Advantageous solutions of the method of the invention have been presented in separate independent patent claims.

The invention is in more detail presented in the description and the attached drawings.

Figure 1 presents

a longitudinal cross section of a typical machine construction (actuator) unit, which is accomplished with the method in this invention and

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Figure 2 presents

a cross-profile of spots Fig 2 - Fig. 2. in Figure 1.

10 Figures 3a - 3C present

some alternative massive motor constructions
of a drum motor.

Figures 4 and 5 present

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a drum motor designed according to the invention and integrated to one end of a vacuum belt conveyor construction, with Fig. 5 being a section along line V - V of Fig. 4.

Referring to Figures 1 to 3, the object of this invention is a construction in electric motor drive, where a so called solid asynchronous motor, which has a stator 2 mounted on a non-rotatory shaft 1 and around the stator is a rotor 4, which is, like by means of bearings 3, rotary connected on the same shaft 1 and has a short-circuit arrangement, is designed to drive a machine construction (actuator). The functional part of the machine construction (actuator), like conveyor's 5 driving roll 5a or 5b or 5c is designed to operate by integrally connected short-circuit arrangement as the rotor 4 of the asynchronous motor. Especially in Figure 3c is shown the most simple structure of the invention, in which conveyor's driving roll 5a is realized with a

solid shell, which operates directly as the short-circuit arrangement of the rotor 4 without any traditional laminated rotor component with short-circuit conductors (e.g. short-circuit bars and rings).

5 The solution according to this principle is also shown in Figure 3b, where driving roll 5b is designed to operate as the rotor of the asynchronous motor with the solid shell having on its inner surface drilled or machined holes or grooves.

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Different from Figures 3b and 3c, the invention may be advantageously used in connection with the structure, where the short-circuit arrangement can be realized in the rotor's shell 4a with short-circuiting conductor bars 4b and rings 8. In this connection short-circuiting connector bars 4b and rings 18 are arranged to operate at least partly internally of

the rotor's shell 4a operating as functional part of the machine construction (actuator), such as conveyor's driving roll 5c. This type of solutions are presented especially in Figure 2, where round short-circuit bars 4b are being used and in Figure 3a where quadrangular short-circuit bars 4b' are being used in rotor shell 4a'. The bars 4b shown in Figure 2 may be hollow, so that each bar comprises a channel 4c for piping cooling fluid. At each end of shell 4a, a flange 7 is provided which connects the shell to one of the bearings 3.

30 In Figure 3a is shown a design, where conveyor's driving roll 5a is realised by a solid shell having quadrangular short-circuit bars on its inner surface. This type of electrical motor design should be used

when a compact drum motor constructions (e.g. maximum outer diameter and total length of the drum motor are limited) with high output power and torque are desired. Such a compact drum motor is needed in vacuum belt conveyors used for "tail threading" in paper machines.

A typical design of drum motor's stator component 2 consists typically a pile of 0,3 - 1,0 mm thick electrical sheets 21 which are mounted on a stationary hollow shaft 1 and fixed at their position by spot welding stator end plates 20 to the stationary shaft. Stator windings 6 are connected via electrical connection cable 19 to an external electric grid.

Figures 4 and 5 show one end of a vacuum belt conveyor comprising an endless air pervious belt 10 which - in operation - travels across two rotary pulleys, only one pulley 4 being shown. The pulleys are supported by a vacuum box 11. Therein a negative pressure will be created by any vacuum source (not shown). The negative pressure will propagate through openings 12 of a cover plate 13 and through belt 10 in

order to convey a web of paper or similar material, in particular a lead strip or "tail" which has been separated from threading purposes (see e.g. US patent 3,355,349).

In order to drive the belt 10, a pulley 4 is designed as the rotor of an electric motor drive according to the present invention. Similar to Figure 1, a stationary hollow shaft 1 supports a stator 2 and (by means of bearings 3) the rotor 4, - which is the pulley

of the vacuum belt conveyor - and which again comprises a rotor shell 4a and two end-flanges 7.

Preferably, the following measures may be provided in order to adapt the electric motor drive to the demands of a vacuum belt conveyor:

The width W of conveyor 5 (and also the length L of the pulley's shell 4a should be relatively small, about 0,25 m. The pulley's diameter should preferably be less than 0,15 m. On the other hand, the speed of the belt should be about the same as the operating speed of modern paper machines which may exceed 2000 m/min. Therefore, there is a need for very high motor output while the dimensions of the motor drive should be relatively small.

To fulfil these demands, the distance D between the bearings 3 is larger than the length L of the pulley's shell 4a, in order to increase the internal space being available for stator 2 and for the short-circuit arrangement of the rotor 4. As a consequence, each flange 7 is formed as a bushing which bridges the difference between length L and distance D.

Furthermore, each of the supporting brackets 8 which connect the stationary shaft 1 to the side walls of the vacuum box 11 is formed similar to a Z (in other words: it is "double

folded"). In addition, each support bracket 8 may be wrapped around the periphery of one of the flanges 7.

In order to improve the cooling effect, the hollow shaft 1 comprises at one of its ends an internal (e.g. coaxial) supply channel (15) as well as a discharge channel 16, as a result, all the cooling fluid X must
5 pass the inner side of stator 2 as well as its outer side and the inner side of the rotor (plus the channels 4c, if existing, in the bars 4b in Figure 1).

Also, the following is advantageous: The above
10 mentioned supporting brackets 8 can be used also as a connection surface for vacuum belt conveyor's accessories (e.g. knife plates, rotary rippers and choppers) (which is not shown as practical solution in enclosed drawings).

15 In addition to the things mentioned above, the cooling of the machine construction (actuator) operating as a rotor of a asynchronous motor is realized advantageously mainly with primary cooling by carrying
20 over-press cooling air X in axial direction through the stator shaft 1, which can be for example a hollow shaft, pipe or similar and it is equipped with it's first flow arrangement 1a. On the other hand when using advantageously the structure of this invention it is
25 possible to boost the cooling of the asynchronous motor besides what was described earlier or instead of it also with secondary cooling by equipping the short-circuiting bars 4b' with another flow arrangement 4c. Then, for example, it is possible to carry cooling air
30 X in axial direction through the hollow copper short-circuit bars 4b, for example, according to the principle in Figure 1 with the help of the holes 1b in the stator shaft 1 together with the primary air flow

1a which take place together with the parallel flow to the hottest sports of the rotor, which helps to get higher output from the machine construction (actuator) and especially to improve to carry the short run starts/stops.

Once an asynchronous motor has a solid rotor's cross section as shown in Figures 3a, 3b and 3c, cooling is taken care of an air flow arrangement through an air gap which locates between an inner surface of a rotor shell 5a, 5b, 5c and an outer surface of stator component 2.

Further advantageous solution of the structure of the invention is to manufacture the rotor of electric conductive compound metal structure, where copper short-circuit bars 4b; 4b' are integrally connected to the steel rotor shell 4a; 4a' for example by explosion welding or by centrifugal casting.

It is possible with the asynchronous motor realized according to the invention when using especially star type coupling for windings, to get the output of the drum motor equipped with three, four, or six pole stator windings always reach the level 0,5 - 500 kW and to have the speed of rotation typically in the area of 0 - 20000 rpm.

As a further advantageous development (which is not shown in enclosed drawings) it is advantageous to benefit the frequency transformer used by the asynchronous motor, which is equipped with active rotation speed control. In this connection rather

traditional solutions can be used to achieve the wanted effect.

The object of this invention is also a method with an electric motor drive, where the machine construction (actuator) is used by a asynchronous motor, such as drum motor, which has a stator 2 mounted on a non-rotatory shaft 1 and around the stator is a rotor 4, which is rotatory, like by means of bearings 3, connected on the same shaft 1 and has a short-circuit arrangement. The functional part of the machine construction (actuator), like conveyor's 5 driving roll 5a, is arranged to operate by having short-circuit arrangement as the rotor 4 of the asynchronous motor (typical constructions shown in Figures 2 and 3a). The method according to this principle is applied in simplest way for example in constructions in Figure 3b, wherein driving roll's 5b machined grooves/slots 5d are arranged as the short-circuit arrangement. On the other hand in Figure 3c is a similar type of solution without traditional short-circuit bars, wherein the driving roll 5a is realized a solid shell, which operates directly as the short-circuiting arrangement.

Furthermore as an advantageous application of this method it is advantageous to benefit it with asynchronous motor, whose short-circuit arrangement is connected to the rotor 4, like short circuiting bars 4b and rings 8 are supported on rotor's shell 4a. In this connection short-circuit bars and rings belonging to the short-circuit arrangement are arranged to operate at least partly internally as the rotor's 4 shell 4a of the operating functional part of the machine

construction (actuator), such as conveyor's driving
roll 5a. In this connection this type of solution is
presented, especially in Figure 2, showing round short-
circuit conductors 4b and further in Figure 3a showing
5 quadrangular short-circuit bars 4b'.

Furthermore referring to Figure 1 this method can be
used with an asynchronous motor which is arranged to be
cooled by having a fluid flow. The cooling of the
10 asynchronous motor is realized as a closed system by
carrying cooling fluid, such as over-pressure cooling air
X, hermetically essentially in axial
direction in a primary flow arrangement 1a through the
stator shaft 1 like hollow shaft, pipe or similar. On
15 the other hand the cooling of the asynchronous motor
can be arranged instead of as described above by
carrying cooling fluid, such as over-pressure cooling air
X hermetically essentially in axial direction in a
secondary flow arrangement 4c provided in short-circuit
20 conductors 4b like hollow bars or pipes.

Especially referring to Figure 1, as an example: Rotor
4 of the solid asynchronous motor is manufactured of
electric conductive compound metal structure, when
25 advantageously, for example, copper short circuit bars
4b which are welded, like explosive welded or butt
welded into the holes in the steel rotor shell 4a or
that they are cast integral with a most suitable
casting method, like press casting method (solution is
30 not presented in Figure 1). With above mentioned
methods every short-circuit bar 4b and ring 18 is
integrated as an integral part of rotor shell 4a, which
allows to achieve better heat transmission between the

steel shell and copper short-circuit conductors. This fact has a great importance when trying to get higher maximum power from the machine constructions (actuators) than with traditional solutions and especially when short run starts/stops are in question. The same is true with the embodiment shown in Figure 3a comprising rotor shell 4a' and bar 4b'.

It is obvious that this invention is not limited to the above mentioned or explained solutions, it can be considerably modified within it's basic idea. Thereby it is possible firstly to utilize the construction or arrangement of this invention in most different connections, whereupon the dimensions and constructions can considerably differ from the hereby presented example drawings. On the other hand other type of fluids can be used in the cooling of the asynchronous motor realized according to the invention or the cooling can be done differently from what presented above.